

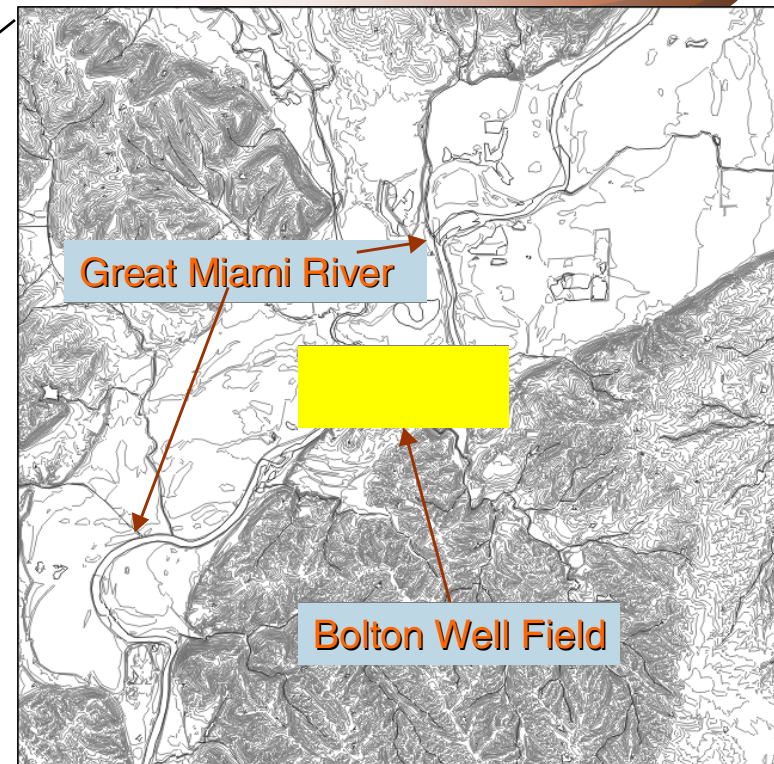
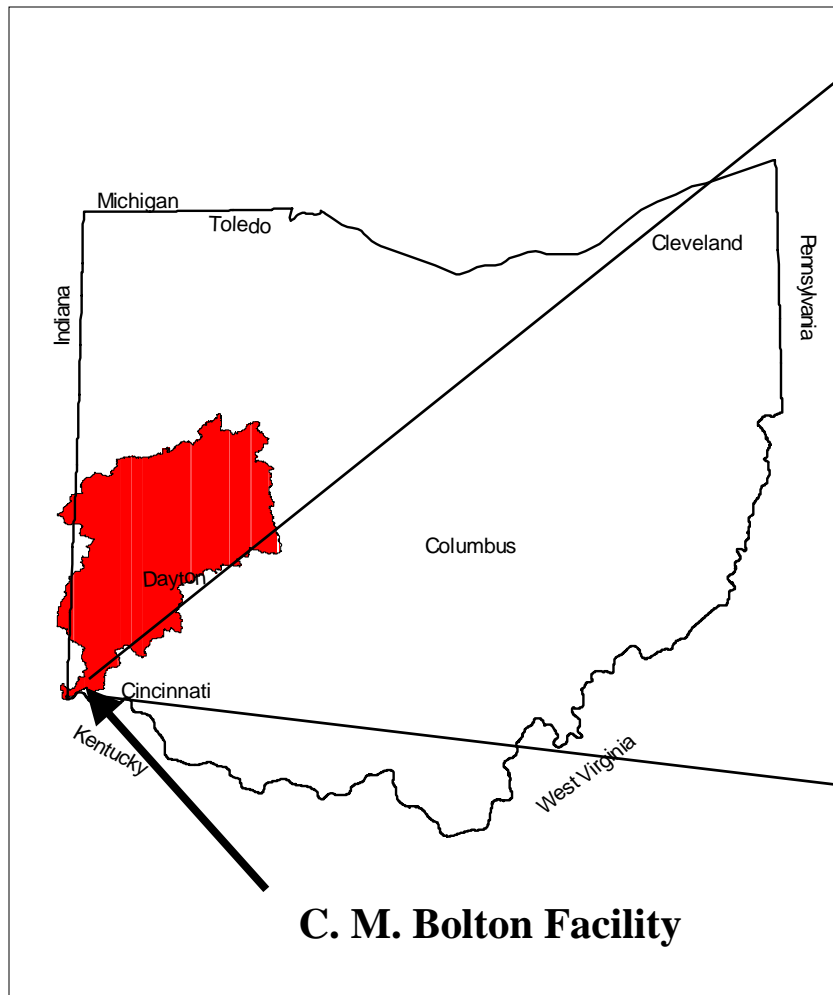
Induced Infiltration Rate Variability and Water Quality

*-Part of a cooperative Flowpath Study with the U.S.
Geological Survey, Miami University and the Ohio Water
Development Authority*



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Great Miami River Watershed and Buried Valley Aquifer




Charles M. Bolton Well Field

- Ten vertical wells spaced 600' to 1,125' along 1.5 mile reach of Great Miami River
 - depth - 81' to 186'
 - screened lengths - 30' to 90'
 - horizontal distance from river - 50' to 810'
- Well field production
 - approx. 2,700 gpm (4.0 mgd) each
 - average daily production - 15 mgd from 4 wells
 - maximum daily production - 34 mgd from 10 wells
 - relies on induced infiltration to sustain yield
 - 30% to 50% surface water under steady state
 - >60% surface water after storm events (??)

Basis for Project: Production Well Microscopic Particulate Analysis Data

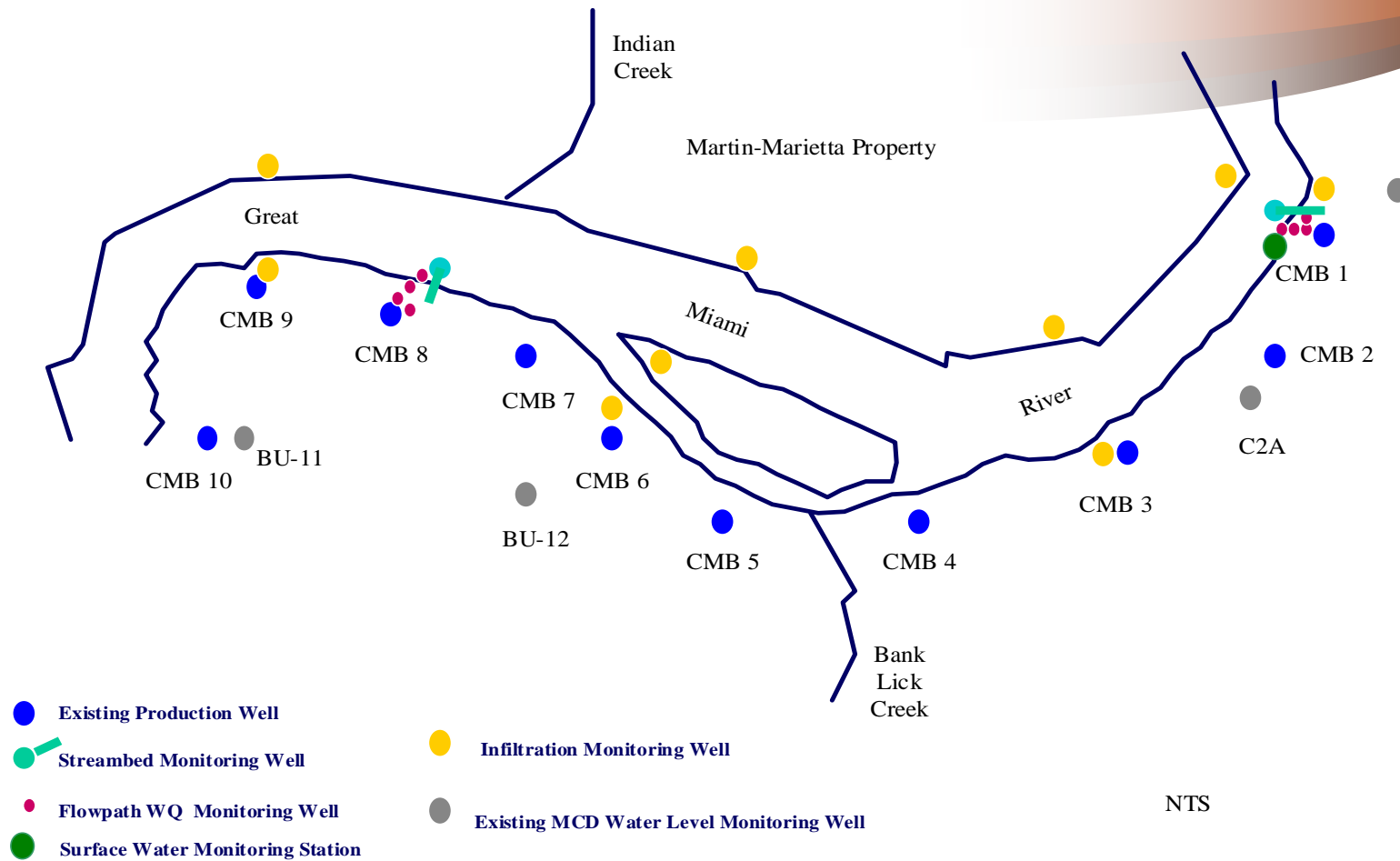
- 104 MPA samples collected from 1992 to present
- Collected under various river stage conditions; with emphasis after high river stage events
- 53% of samples were non-detect for “surface water indicators” (algae, etc); 47% contained indicators (65% low risk, 26% moderate risk; 9% high risk)
- Questions:
 - Why do algae occur sporadically in production well samples?
 - Is it due to hydrologic variability?
 - Is GW at risk for *Giardia* & *Cryptosporidium* (GWUDISW)?

Goal of GCWW/USGS/MU Flowpath Study




- Goal: To develop a method for evaluating natural filtration at riverbank filtration sites
- Objective: To identify any relationship between changes in the rate of induced infiltration and water quality variations

GCWW - C. M. Bolton Well Field with Flowpath Wells



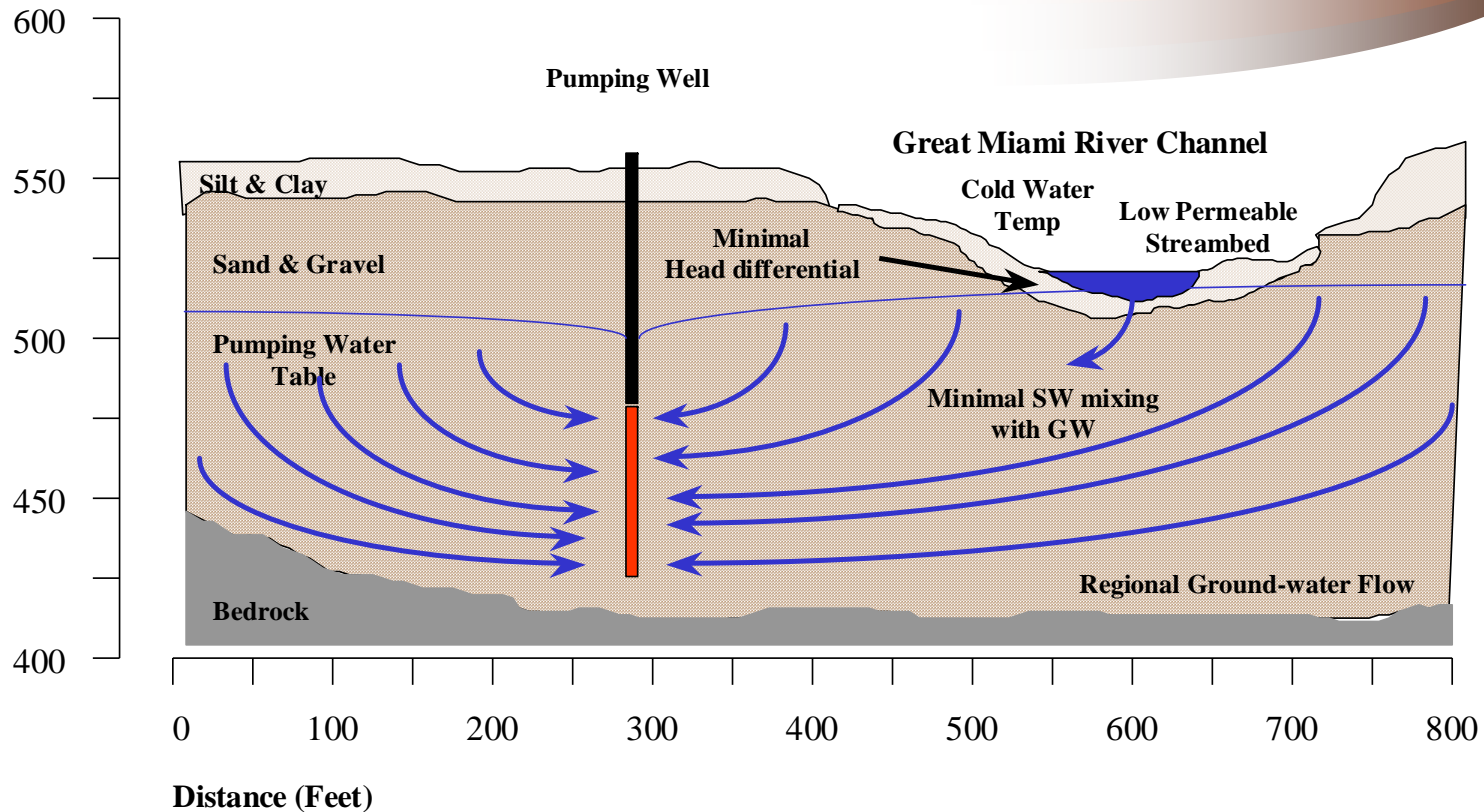
Factors Influencing the Rate of Infiltration



- River stage elevation
- Ground water elevation
- Streambed permeability
- Streambed thickness
- Streambed area (stage)
- Surface water viscosity (temperature)

Conditions for Minimal Induced Infiltration

Elevation (Feet)

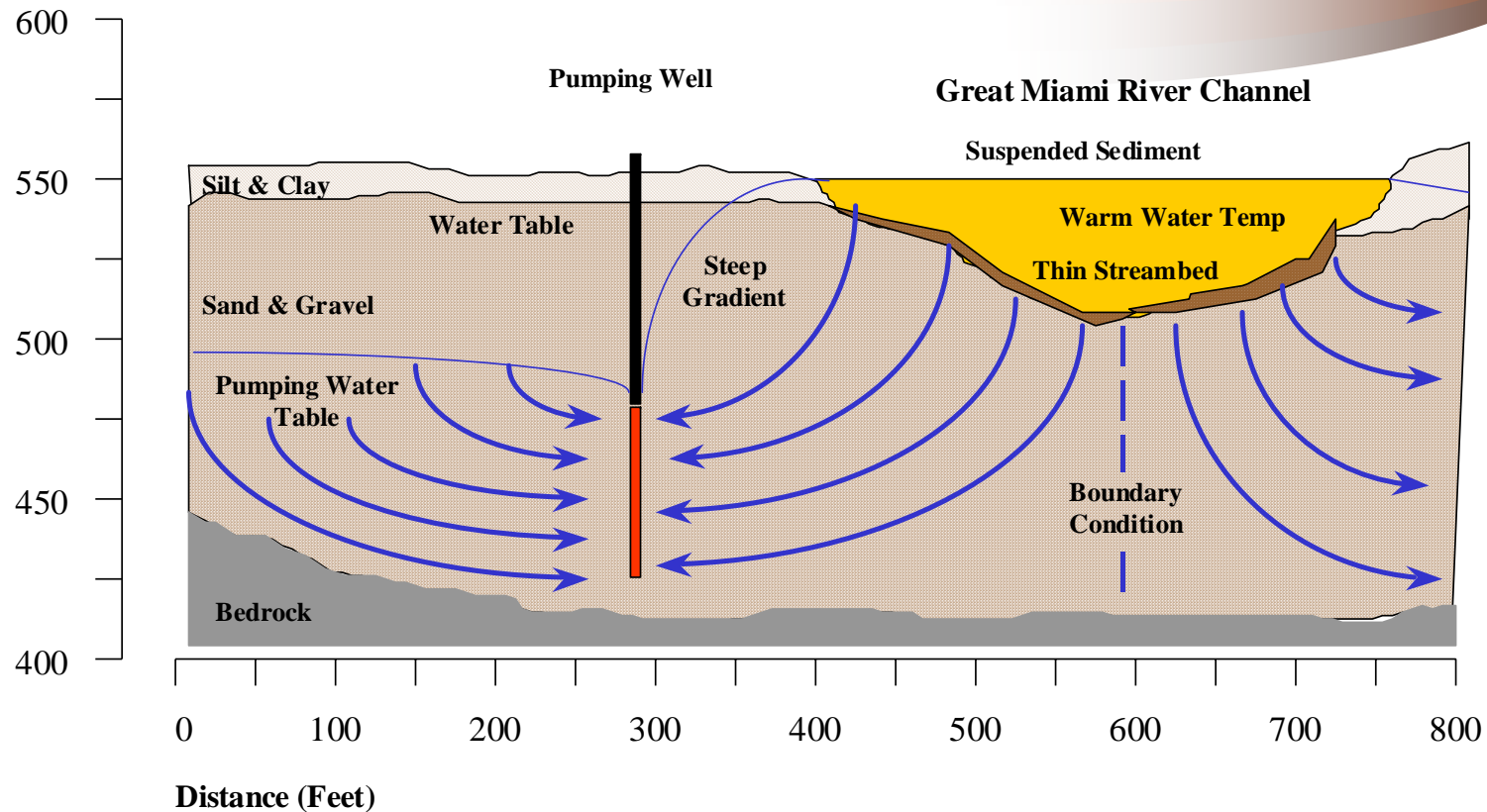


V/H Exaggeration: 1/2



Conditions for Maximum Induced Infiltration

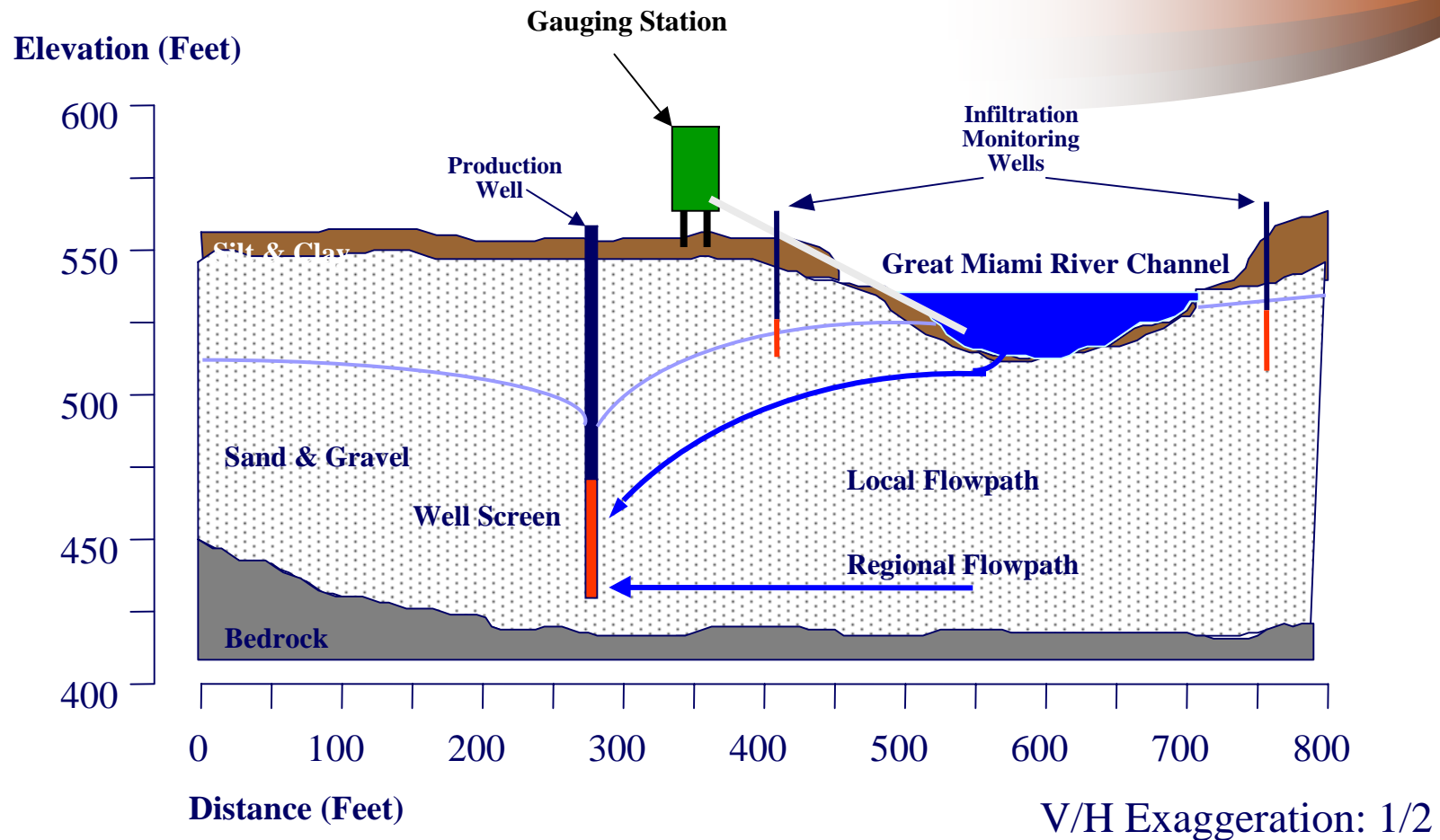
Elevation (Feet)



V/H Exaggeration: 1/2



GCWW/USGS/Miami U Flowpath Study - Infiltration Monitoring Setup



Methodology - Hydrologic Monitoring



- River stage elevation - recorded at half hour intervals at the USGS gauging station
- Ground water elevation
 - recorded at 1 hour intervals at FP1A (between production well and river)
 - recorded at 2 hour intervals at FP1E on opposite side of river
- Surface water temperature - recorded at 1 hour intervals at USGS gauging station
- Period - Sept, 1999 to May,2001

Methodology - Induced Infiltration Rate Spreadsheet Model

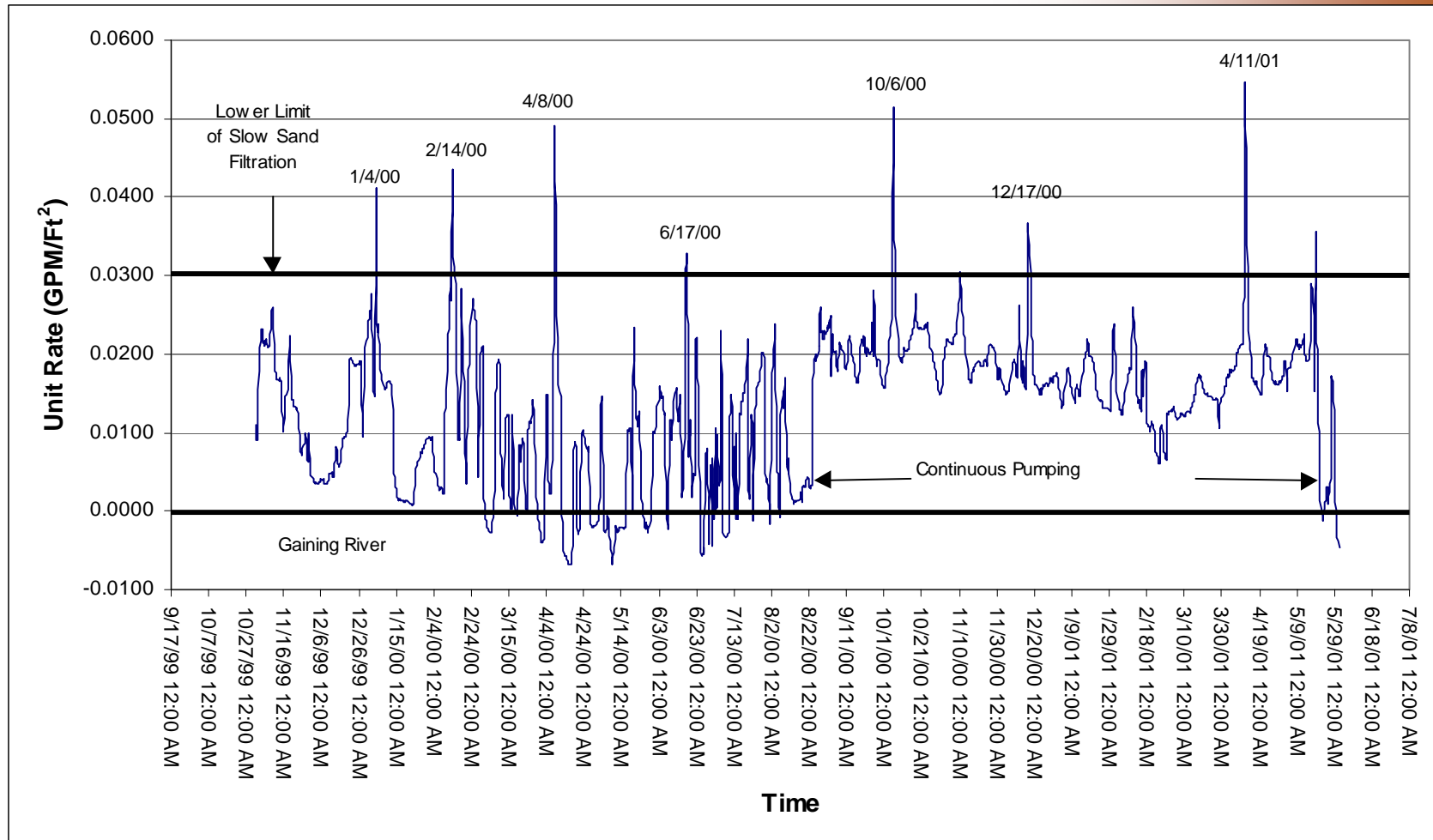


- Estimates the potential average unit rate of infiltration (gpm/ft²)
- Input data
 - river stage - 532.1 ft to 545.5 ft (Δ 13.4 ft)
 - ground water elevation under river - 526.4 ft to 537.6 ft (Δ 11.1 ft)
 - river water temperature - 0.1°C to 29.4°C (Δ 29.3°C)
 - streambed permeability - 0.1 to 1.5 ft/day (1.5 ft/day)
 - streambed thickness - 0 ft to 5 ft (1 ft ??)
- Assumptions:
 - streambed permeability remains constant at 1.5 ft/day
 - streambed thickness remains constant at 1.0 ft

Methodology - Water Quality

- Parameters
 - turbidity, aerobic spores, particle counts (oocyst & cyst size), Heterotrophic Plate Counts, Total Coliform, Microscopic Particulate Analysis (total algae), *Giardia* & *Cryptosporidium* (Method 1623)
- Locations
 - river, production well 1
- Frequency
 - turbidity - weekly, increased to daily during continuous pumping
 - spores, particle counts, TC, HPC - weekly & daily during “TOT based event periods”
 - MPA, G&C - monthly & multiple samples during “TOT based event periods”

Potential Average Unit Rate of Infiltration



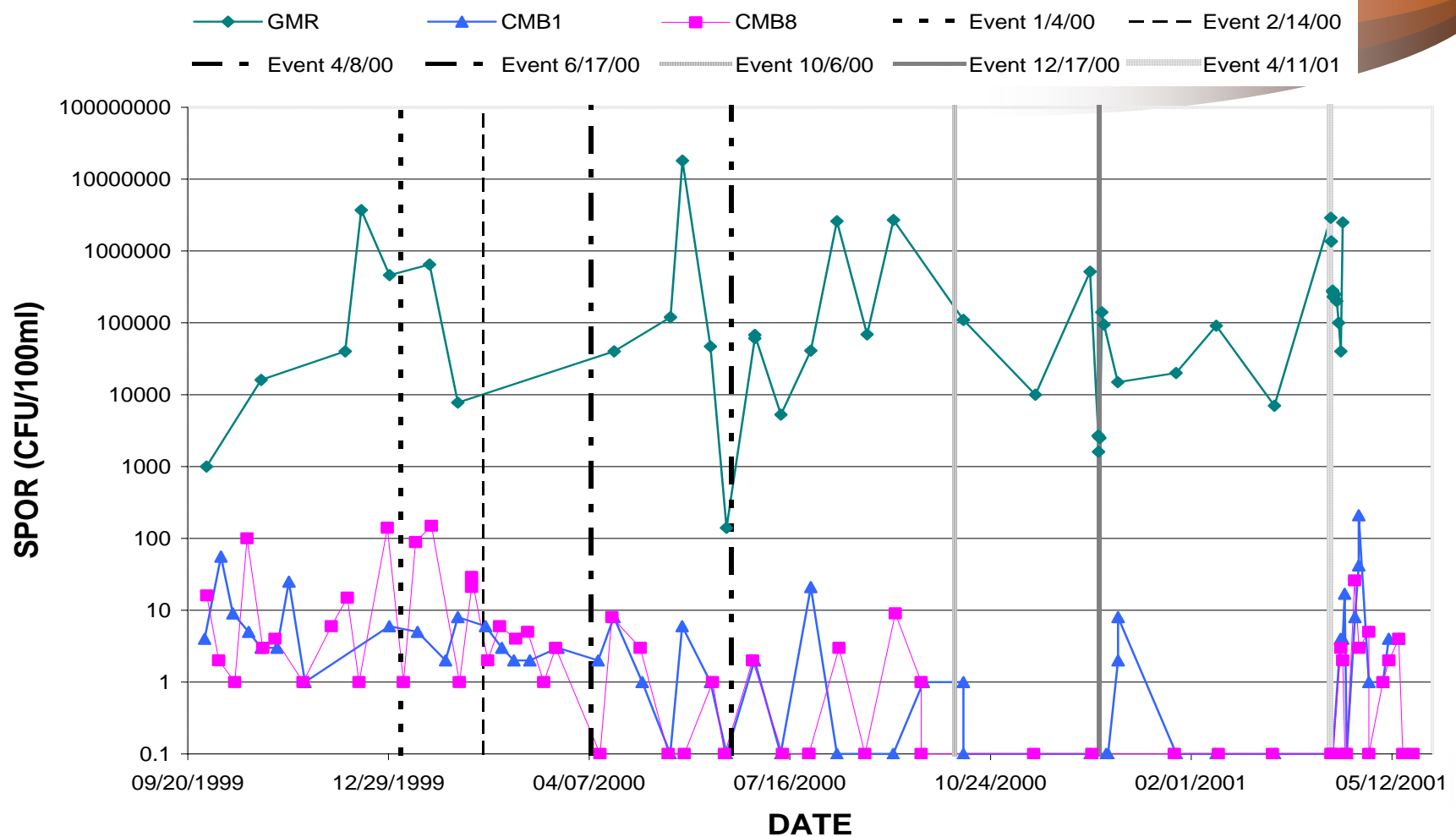
Giardia/Cryptosporidium Results



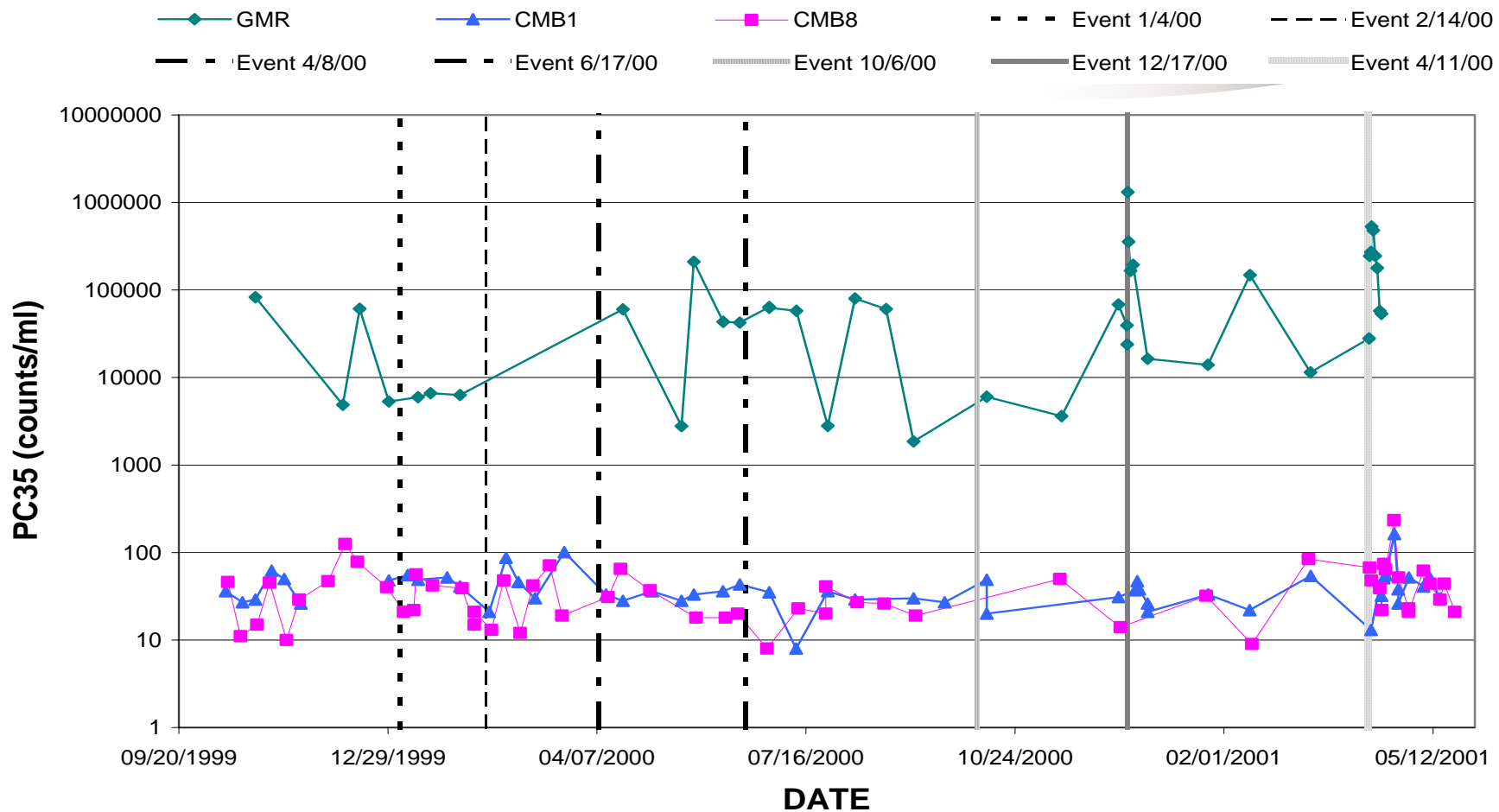
- Great Miami River - *Giardia*
 - ICR Method - 12 month geomean - 5.63 cysts/100L
 - Method 1623 - 12 month running ave = 63 cysts/100L
- Great Miami River - *Cryptosporidium*
 - ICR Method - 12 month geomean - 1.37 oocysts/100L
 - Method 1623 - 12 month running ave - 86 oocysts/100L (Bin 2)
- CMB Production Well 1
 - ICR Method - 6 samples - no detects
 - Method 1623 - 12 month running average - no detects (Bin 1)
- **Note:** Of 285 ground-water samples (71% analyzed using Method 1623), no G/C detections have been found



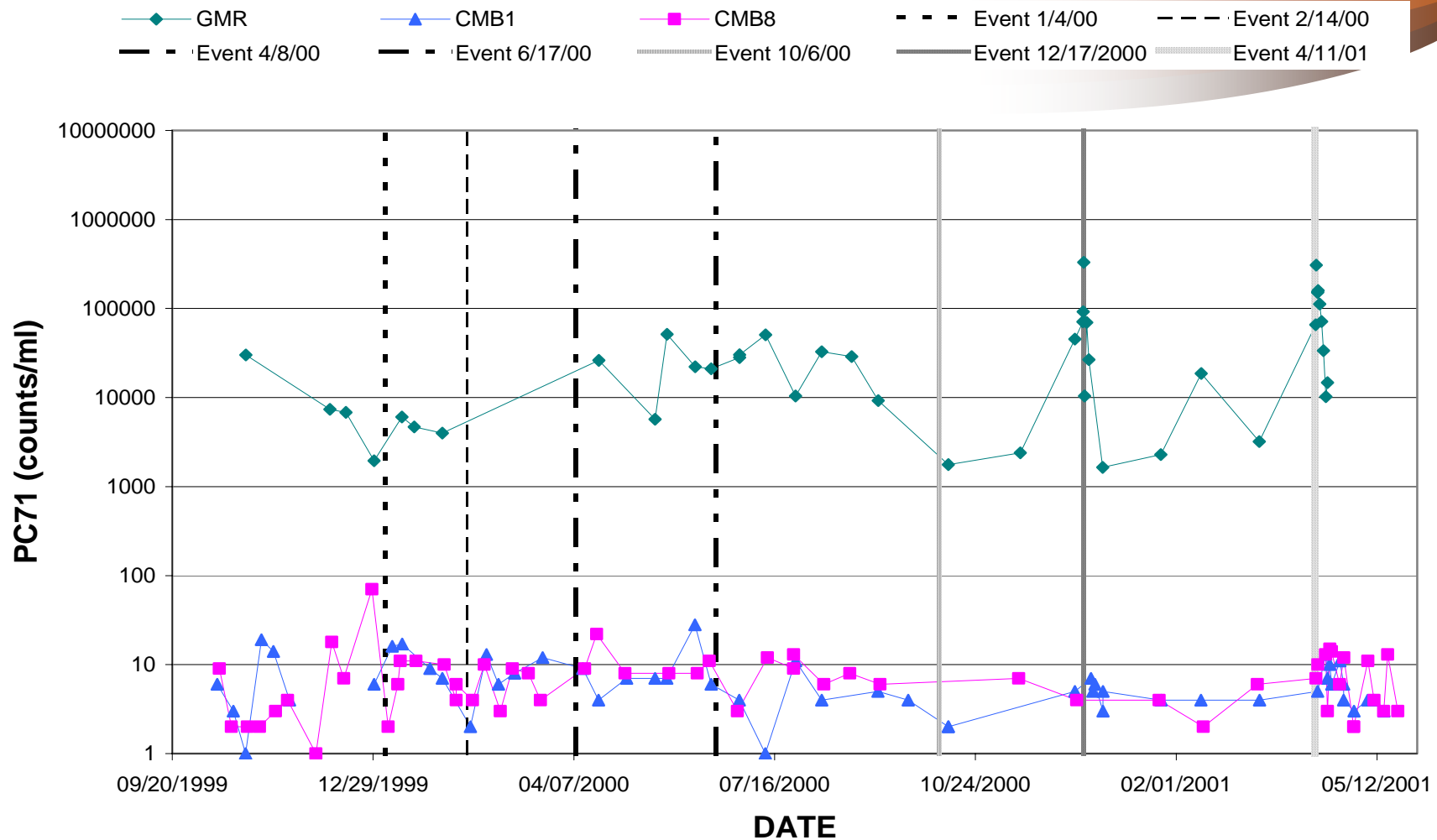
Spore Results



Particle Count Results (3-5 micron)

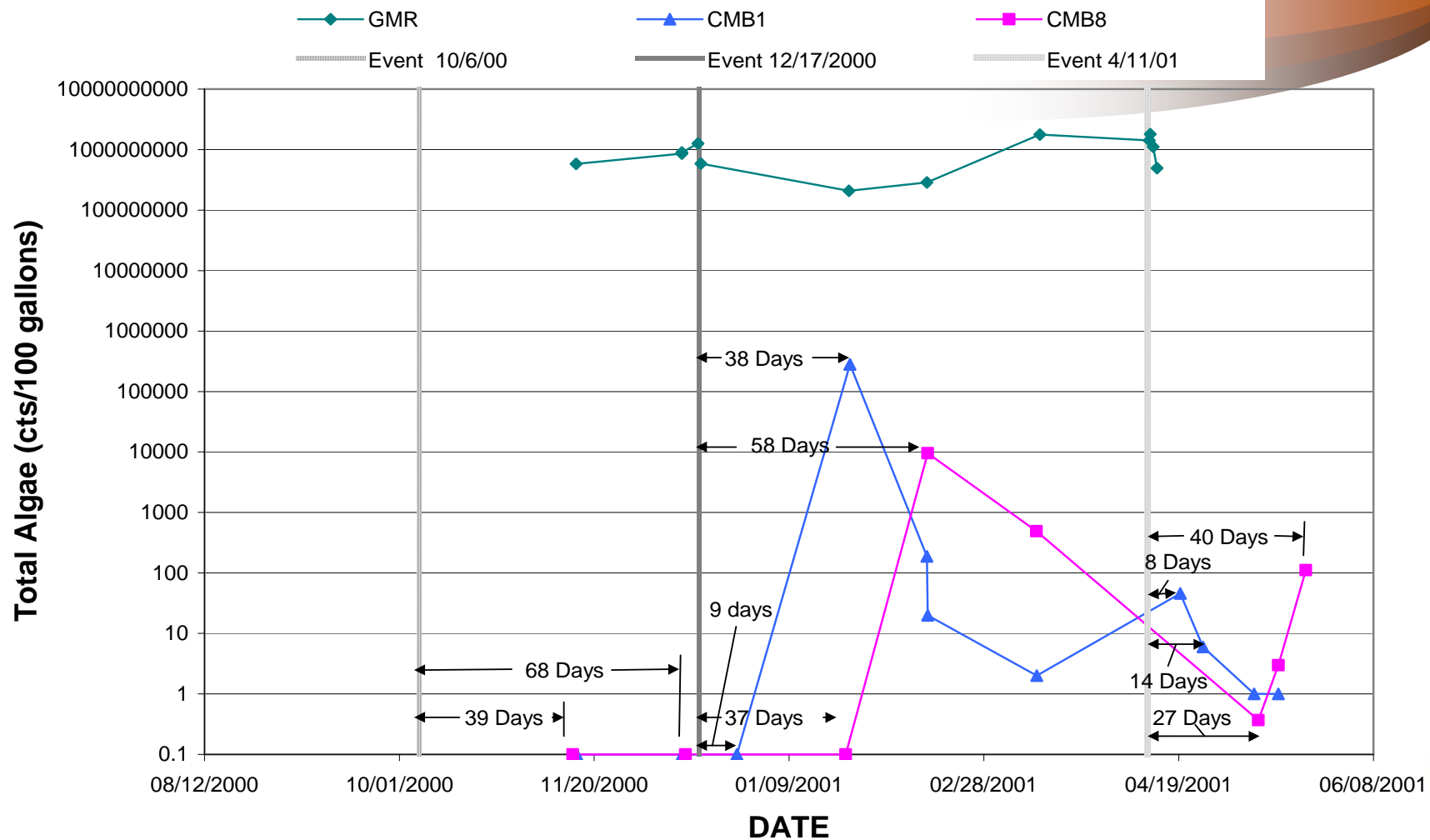


Particle Count Results (7-15 micron)

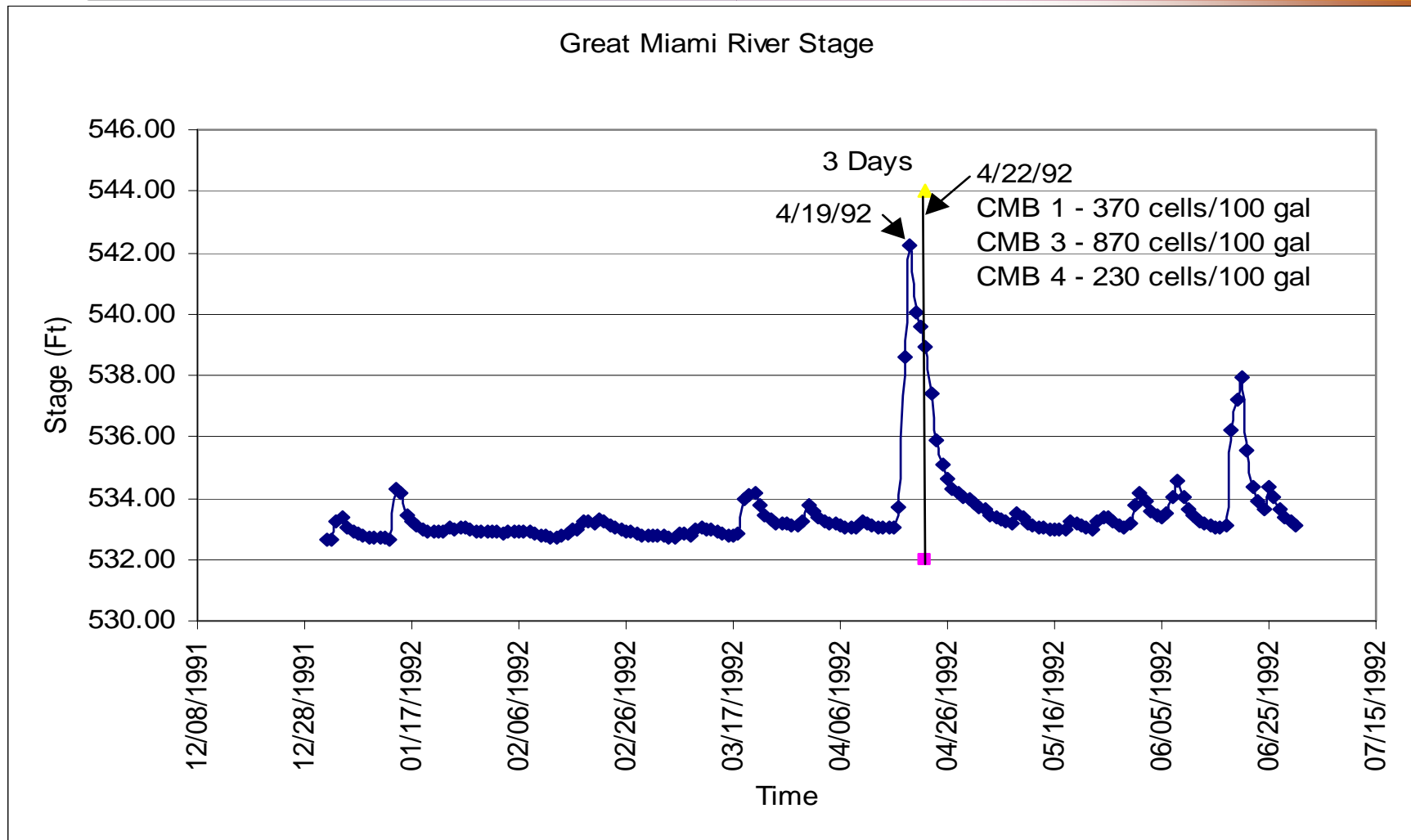


Total Algae Results

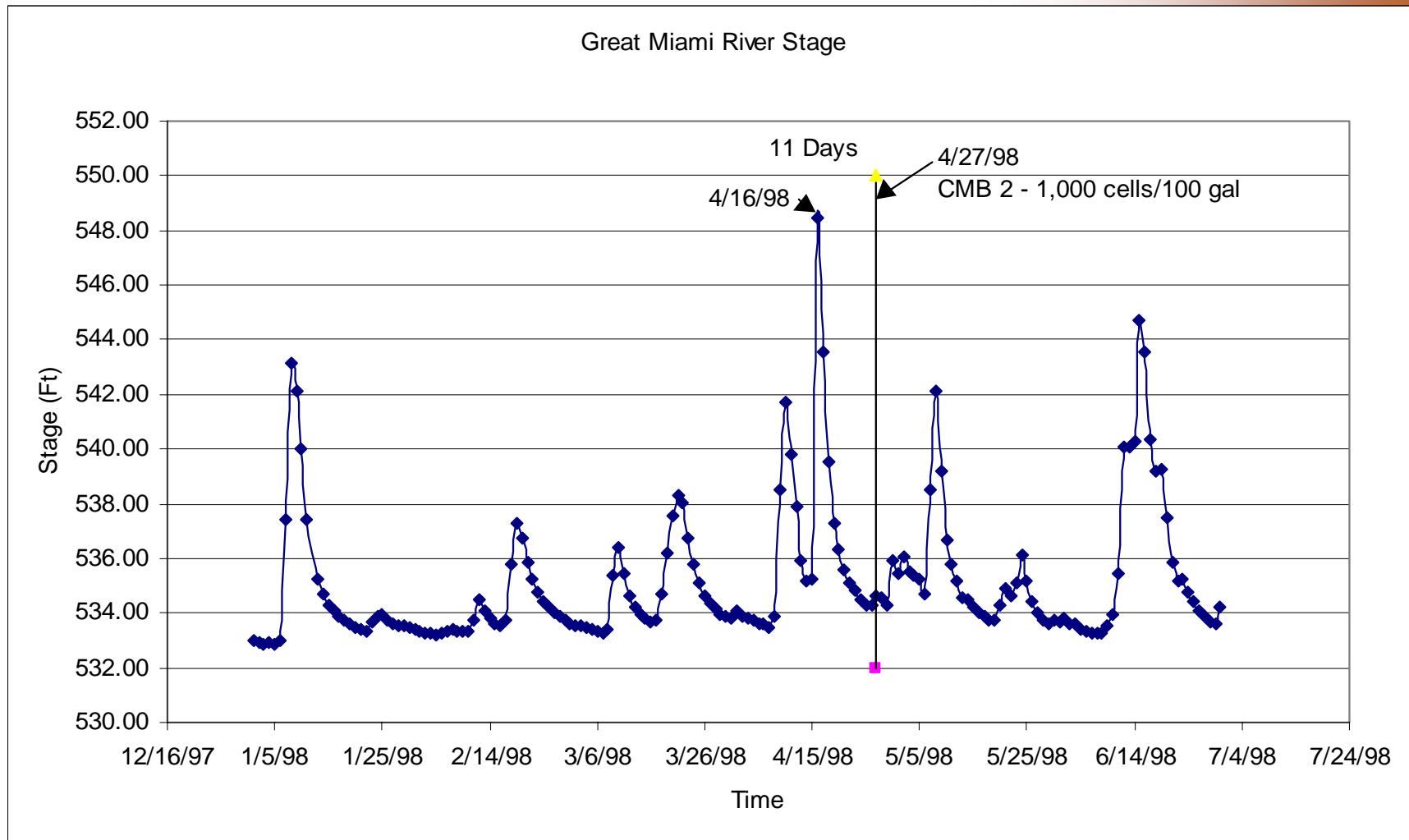
(Microscopic Particulate Analysis)



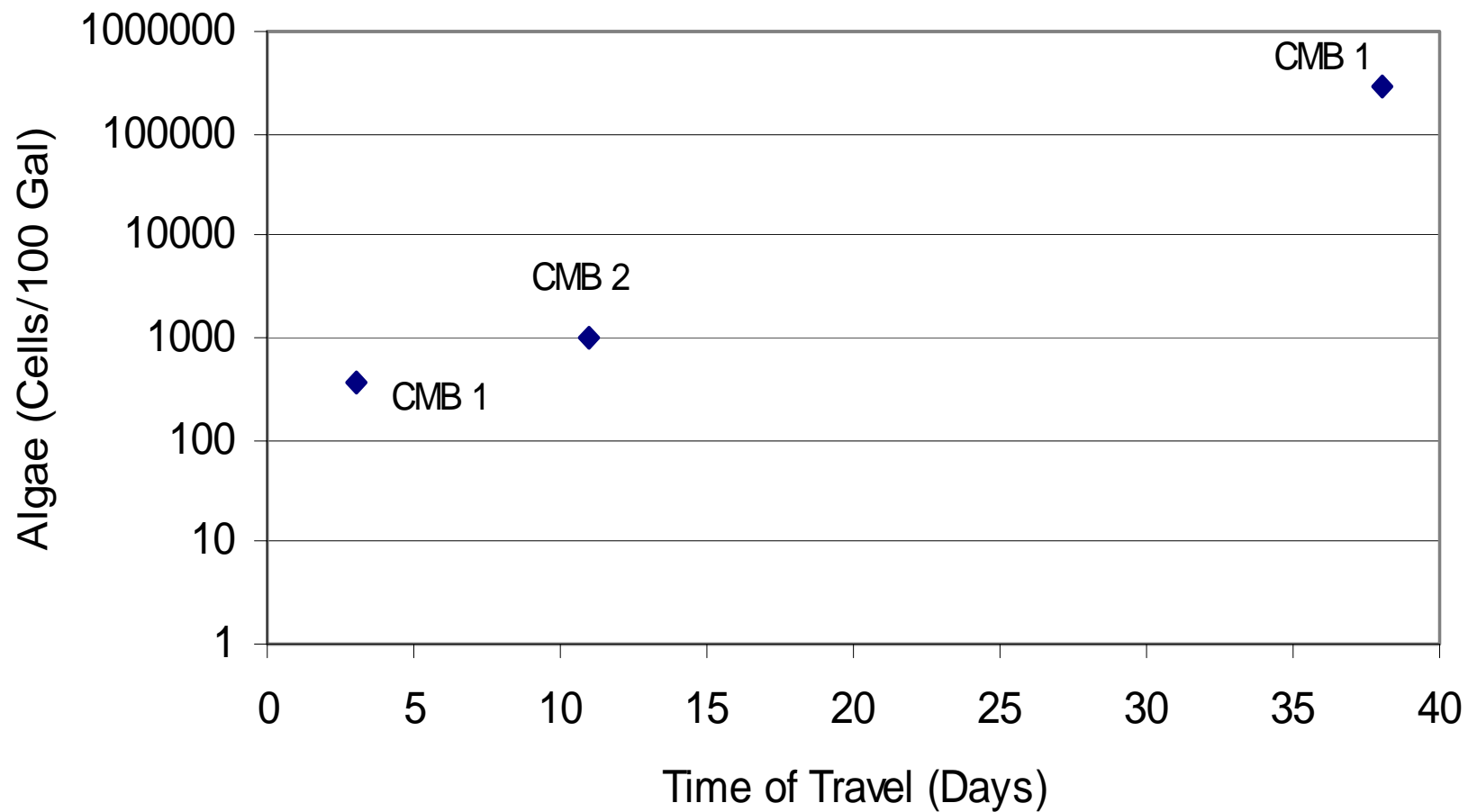
Previous MPA Data (1992)




Previous MPA Data (1998)



Algae Concentration versus TOT



Frequency of High Infiltration Events

- 
- Occurrence is low
 - Flowpath Study - 576 days
 - 8 “events”
 - typically 2 days of highest rate
 - 16 days of high risk
 - 2.7%
 - See “Whitteberry” talk for longer period of record

General Conclusions



- The unit infiltration rate is well below that of slow sand filtration; Peaks occur within the lower range.
- Several surrogate indicators show minor fluctuations
- MPA data (previous & flowpath) suggests that algae TOT is longer than TOT of ground water (still inconclusive; needs more research)
- Not able to establish correlation between surface water indicators and *Giardia/Cryptosporidium*
- Riverbank filtration is highly effective for microbial removal from surface water